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Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,422,150,** on March 13, 2003, by **TESCO CORPORATION,** assignee of Robert Tessari and Bruce Houtchens, for "Method and Apparatus for Drilling a Borehole with a Borehole Liner".

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METHOD AND APPARATUS FOR DRILLING A BOREHOLE WITH A BOREHOLE LINER

Field of the Invention

The invention relates to methods for drilling well bores and in particular methods for drilling a wellbore using a drilling liner.

Background of the Invention

A drilling liner can be carried along behind the pilot bit to line a borehole while it is being drilled. Previously drilling fluid has been circulated down through a drill pipe, through the pilot bit and up the outer annulus between the drilling liner and the borehole wall. Alternately, in other methods, the drilling fluid is circulated down through the drill pipe and forced up through the liner by sealing between the liner and the borehole wall.

In previous methods, drilling with a liner was often not successful, primarily due to drilling fluid pressure losses arising between the bit and the casing. These pressure losses required the use of very high pressures at the bit, which adversely affected drilling success.

Summary of the Invention

In accordance with the present invention, there is provided a method for drilling a borehole comprising: providing a drill string of drill pipe including a center bore and a distal end; a pilot bit at the drill string's distal end and an under reamer for drilling behind the pilot bit; hanging a liner from the drill string, thereby forming an annular space between the drill string and the liner and a second annular space between the liner and the borehole wall; circulating drilling fluid down through the center bore of the drill string out through the pilot bit and through the second annular space between the liner and the borehole wall and up through the annular space between the drill string and the liner.

In accordance with another aspect of the present invention, there is provided an apparatus for drilling a borehole, the apparatus comprising: a drill string of drill pipe including a center bore and a distal end; a pilot bit at the drill string's distal end; an under reamer on the drill string and spaced behind the pilot bit; a liner including an inner bore and arranged with the drill string extending through the liner inner bore; a ported sub mounted between the drill string and the liner to support the liner on the drill string and including a first port for providing fluid communication between the drill string center bore and the outer surface of liner and a second port for providing fluid communication between the liner inner bore and an upper surface of the sub; and a seal extending about the ported sub to seal against fluid communication between the first port and the second port.

In accordance with another aspect of the present invention, there is provided an apparatus for drilling a borehole, the apparatus comprising: a drill string of drill pipe including a center bore and a distal end; a pilot bit at the drill string's distal end; an under reamer on the drill string and spaced behind the pilot bit; a liner including an inner bore and arranged with the drill string extending through the liner inner bore; a ported sub mounted between the drill string and the liner to support the liner on the drill string and including a port for providing fluid communication between the liner inner bore and an upper surface of the sub; and a seal adjacent the upper end of the liner and selected to seal against fluid flow upwardly past the liner upper end through the annulus between the liner and the borehole wall, such that fluid in the annulus between the liner and the borehole wall below the seal creates a fluid lock against drilling fluid returning to surface through the annulus about the liner.

Brief Description of the Drawings

Figure 1 is a schematic sectional view along a wellbore including a drilling system including a drilling liner and showing a method according to the present invention.

Figure 2 is a schematic sectional view along a wellbore including another drilling system including a drilling liner and showing another method according to the present invention.

Figure 3 is a schematic section view along a wellbore showing another drilling apparatus and method according to the present invention.

Detailed Description of the Preferred Embodiments

Drilling with a liner can be accomplished by drilling the liner in place using a conventional drill string 10 formed of drill pipe or coiled tubing. Drill string 10 extends from surface to the bottom 12 of the hole, includes a center bore 13 and can include conventional drilling tools including, for example, a pilot bit 14 and an under reamer 16 driven by a bottom hole assembly 17 including a mud motor. A liner 18 is hung onto drill string 10 by a ported sub 20. Preferably, ported sub 20 is connected at the up hole end of the liner, while the lower end of the liner is open about the drill string or ported to allow fluid therein. A liner hanger 19 is provided to support liner 18 within casing liner 22, when it is desired to set the liner.

As drilling commences, the fluid, initially provided through drill string 10, is split to both (i) flow F1 down through the inside of drill string 10 and (ii) flow F2 down through the annulus about the outside of liner 18. Fluid then returns F3 up through the annulus between drill string 10 and liner 18. Fluid passes through ported sub 20 and returns to surface through the annulus F4 between the borehole wall or casing liner 22 and the drill string. The flow F1 provides that there is enough fluid to drive and lubricate pilot bit 14 and under reamer 16 while flow F2 prevents flow up the annulus between the liner and the borehole and forces all drilling fluid to pass up between the liner and the drill string. It has been found that flow through this annular space causes less pressure loss than flow through the annular space between the liner and the borehole wall.

Ported sub 20 can include at least one port 24 through which the fluid flow is split. Port 24 opens between drill string center bore 13 and the outer surface of liner 18 so that fluid

can be diverted from the drill string inner bore to the annular space about the liner. Preferably, the flow through port is controlled so that only a portion of the flow passes through that port with the remainder continuing down through center bore 13 to the pilot bit. For example, a flow restrictor 25 can be installed in port 24 to provide resistance to fluid flow through the port.

Ported sub 20 also includes at least one port 26 through which flow F3 can pass. Ports 26 are sized to permit cuttings to pass.

Ported sub 20 carries a seal 28 such as a packer or swab cups so that fluid is prevented from passing about the liner hanger and prevented from communication between ports 24 and 26, thereby permitting fluid circulation to be controlled about the liner hanger.

Preferably, the drilling is conducted through a borehole liner, such as casing liner 22, that is already cemented in the hole. The drilling proceeds using the above-noted circulation until the liner reaches casing point, which is the point at which it was desired to set the liner in the borehole. The liner can be any length L in order to achieve a selected extension beyond the lower end 30 of the installed casing.

When the liner reaches casing point, the liner can be hung in the casing string, for example adjacent lower end 30, by actuation of liner hanger 19. Ported sub 20 and drill string 10, with attached pilot bit 14 and under reamer 16, can be retrieved through the liner and pulled from the well bore. The under reamer, when expanded, cuts a borehole greater than the outer diameter of the liner, but can be collapsed to be withdrawn through the liner. Thereafter, the drill string can be reintroduced to the liner for cementing through the drill string. In one embodiment, it may be desirable that the drill string and ported sub 20 be removable from the liner at selected times during the drilling process, for example, when it is necessary to replace or repair a bit, under reamer or bottom hole assembly component. The ported sub 20 would then be reconnectable to the liner and the liner hanger would need to be reversibly drivable to release from engagement with the casing.

Referring to Figure 2, there is shown another drilling assembly and method according to the present invention. A liner 18 can be drilled in place using a conventional drill string 10 formed of drill pipe. Drill string 10 extends from surface to the bottom 12 of the hole and can include conventional drilling tools including, for example, a pilot bit 14 and an under reamer 16 driven by a bottom hole assembly 17 including a mud motor, MWD and LWD.

The drill pipe joints 10a are selected to have a limited outer diameter so that there is a clearance between the inner diameter of the liner and the outer diameter of the drill pipe joints selected to permit passage of drill cuttings and fluid.

Liner 18 is hung onto drill string 10 by a ported sub 20 including ports 24 through which a portion of the fluid flow can be jetted into annulus 21. Ports 24 extend from a bore 23 that opens to drill string center bore, through the sub body and open to the outer surface of liner. Ported sub 20 also includes ports 26 through which drilling fluid can pass. Ports 26 are sized to permit cuttings to pass. Ports 26 are not in fluid communication with ports 24.

Liner 18 carries a seal 28 such as a packer or swab cups so that fluid is prevented from communicating between ports 24, 26 through the annulus about the liner, thereby permitting the circulation to be controlled about the liner. Liner 18 also carries a liner hanger 19 for wedging between the liner and the casing 22 when setting the liner in the bore hole.

Stabilizers can be installed to control positioning of the liner and the drill string within the assembly. For example, one or more centralizers 34 can be installed about the liner and one or more stabilizers 36 can be installed between the drill string and the liner. Of course, these stabilizers/centralizers must be formed to permit fluid flow therepast. Stabilizer 36 must also permit the passage of drill cuttings. In one embodiment, stabilizer 36 is fluted to permit passage of drill cuttings and fluid.

As drilling commences, the drilling fluid is initially provided from surface through drill string 10 and is split at sub 20 to flow down both (i) through the inside (F1) of drill string 10 and (ii) through ports 24 into the annulus 21 (F2) about the outside of liner 18. Fluid then returns F3 up through the annulus between drill string 10 and liner 18. Fluid passes through ports 26 of sub 20 and returns to surface through the annulus F4 between the casing liner 22 and the drill string. Flow F2 need only be sufficient to force return flow up between the liner and the drill string, rather than between the borehole wall and the liner.

Referring to Figure 3, there is shown another apparatus and method according to the present invention. Drill string 10 extends from surface to the bottom 12 of the hole and can include conventional drilling tools including, for example, a pilot bit 14 and an under reamer 16 driven by a bottom hole assembly 17 including a mud motor, MWD and LWD.

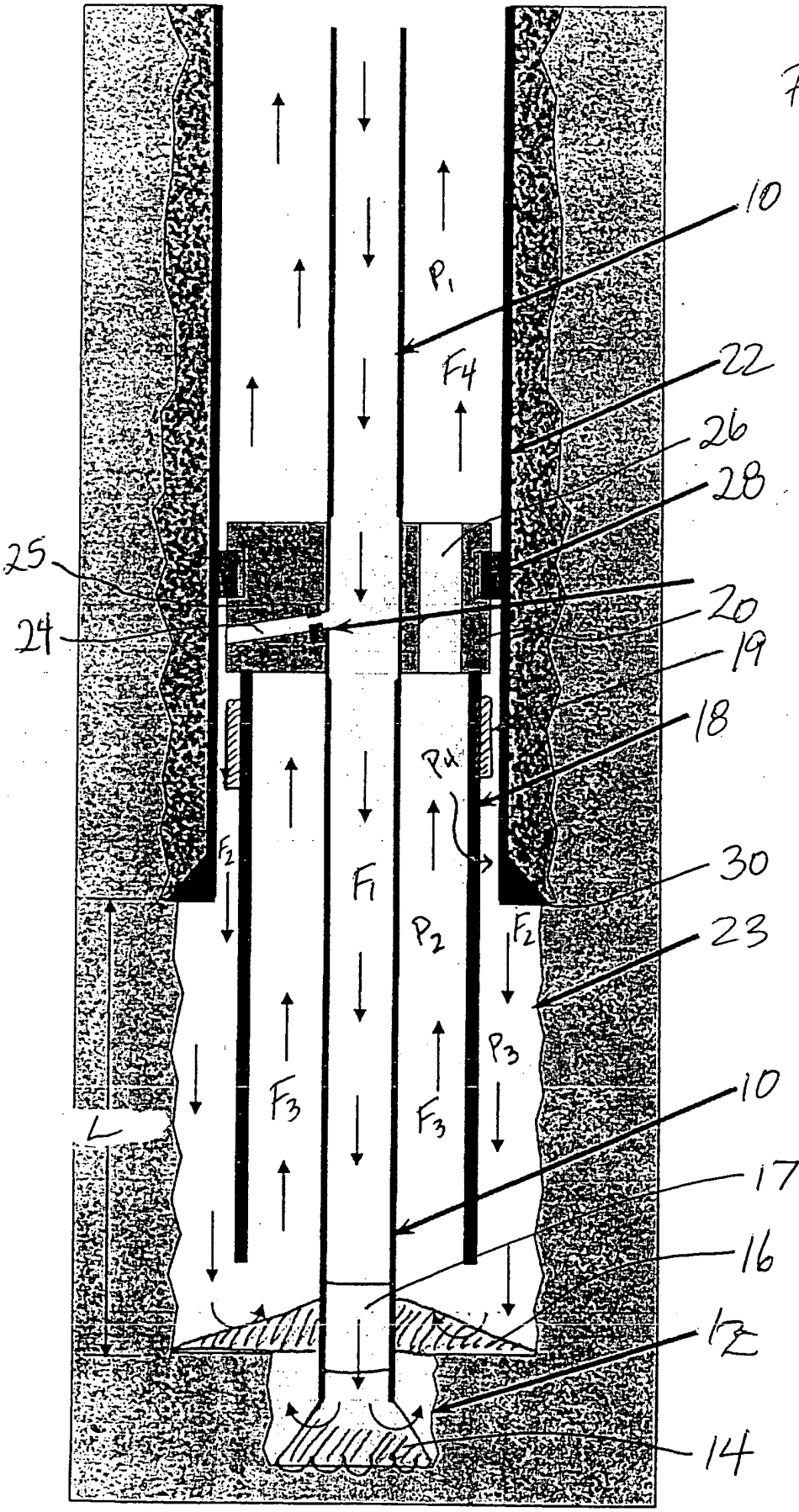
Liner 18 is hung onto drill string 10 by a ported sub 20a including ports 26 through which drilling fluid can pass axially through the wellbore between the liner inner bore and the upper surface of the sub, while returning to surface. Ports 26 are sized to permit cuttings to pass.

Sub 20 carries a seal 28 such as a packer or swab cups so that fluid is prevented from passing upwardly therepast, thereby preventing drilling fluid circulation through the annulus about the liner. Liner 18 also carries a liner hanger 19 for wedging between the liner and the casing 22 when setting the liner in the borehole.

As drilling commences, fluid in the wellbore will tend to be trapped in the annulus about the liner. Drilling fluid provided from surface through drill string 10 flows through the inside (Q1) of drill string 10 and out through the pilot bit. Due to the action of seal 28, fluid trapped in annulus 21 will create a fluid lock forcing drilling fluid to return (Q2) up through the annulus between drill string 10 and liner 18. Fluid passes through ports 26

through sub 20 and returns to surface through the annulus between the casing liner 22 and the drill string.

Figure 1



Liner Drilling Configuration

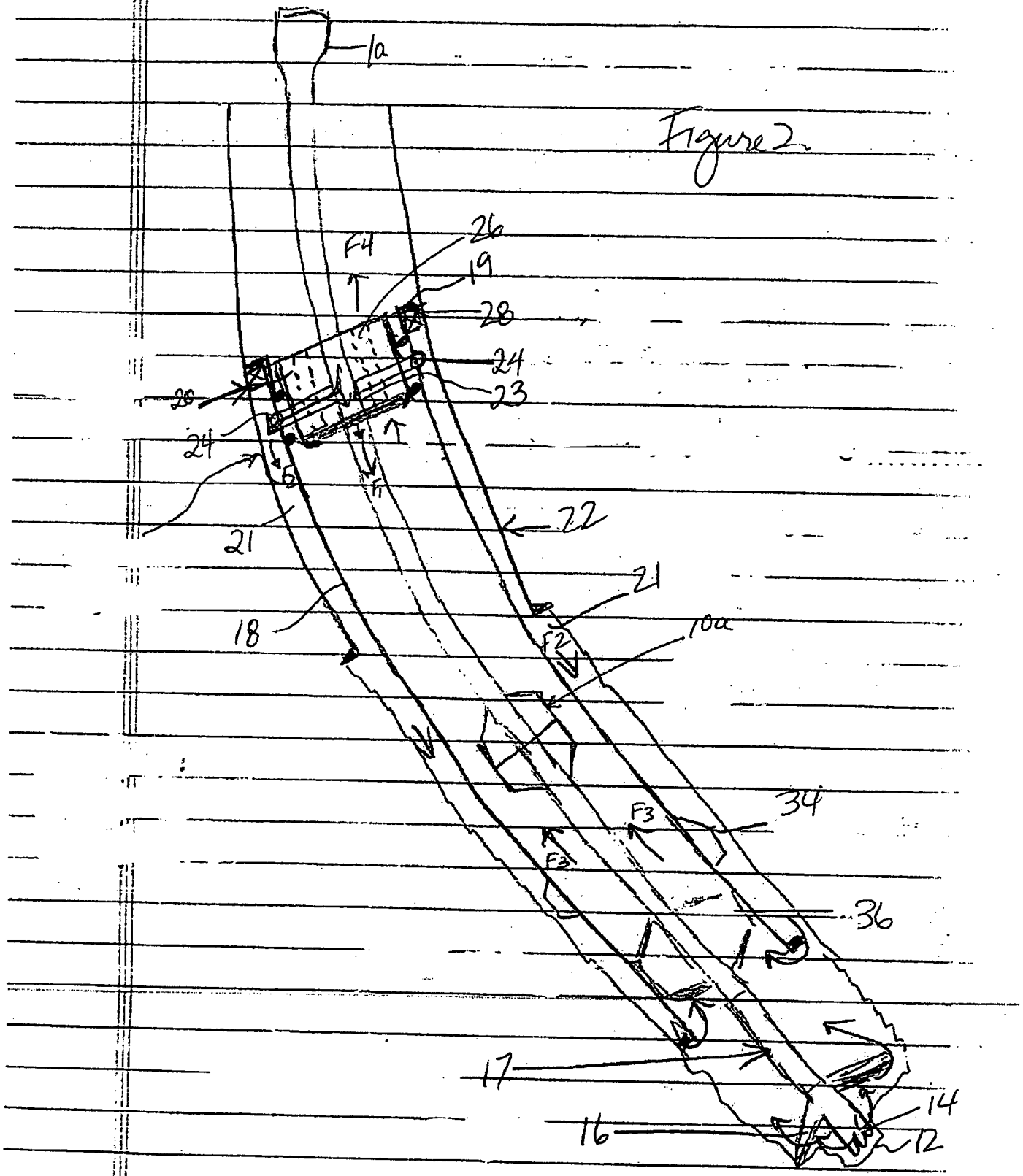


Figure 3.